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CONTENT

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Periodontal disease on individual GJL1.1 from Kotabaru, South Kalimantan, Indonesia *

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Abstract

This article aims to describe the periodontal disease, particularly periodontitis, found on the skeletal remains of an individual dating from the Paleometallic period in Indonesia. The material used for this research is the individual skeletal remains from the Jauharlin 1 Cave site, Kotabaru, South Kalimantan, Indonesia, which lived during the period 1576 ± 15 BP (1410 cal. BP). The periodontitis condition data were collected through macroscopic observation of the maxillary and mandibular alveolar bone. The observation results showed a moderate level of periodontitis, especially in the alveolar bone of the maxillary anterior teeth. In addition, periapical voids were observed in the alveolar bone of the mandibular anterior teeth as well. The morphology suggests the possibility of a cyst developing into a chronic abscess or a hybrid periapical problem. The condition of periodontitis in the maxillary anterior teeth is thought to be caused by a plant-based diet with high carbohydrates. This suspicion was strengthened by a phytolith analysis of soil samples taken from the pelvic cavity of GJL1.1, which showed plant residues from the families/subfamily Arecaceae, Oryzoideae, and Musaceae that is suspected as the GJL1.1 diet. Another factor that is thought to be the cause of periodontitis, including periapical voids, is betel quid chewing. Betel quid ingredients are thought to have triggered inflammation in the periodontal tissues. Consuming betel quid by holding the ingredients in the alveolar area of the right mandibular anterior teeth is thought to be the cause of inflammation in the periapical area.

Keywords: periodontal disease; periodontitis; periapical voids; betel quid chewing

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Introduction

Periodontal diseases are a group of diseases of the gingiva and tooth-supporting structures caused by bacteria in the oral cavity. Common forms of periodontal disease are gingivitis and periodontitis. Gingivitis is irritation and inflammation of the gingiva. Mild gingivitis does not result in any changes to the alveolar bone. Conversely, severe gingivitis can lead to chronic periodontal disease (1,2). Periodontitis is a chronic inflammatory condition of the gingiva. With periodontitis, the bacterial infection spreads to the underlying gingival tissue, destroys the connective tissue to the cementum, and causes pocket formation, alveolar bone resorption, tooth mobility, and finally leads to tooth loss (3). Both gingivitis and periodontitis increase in severity with age (4).

Several types of bacteria influence the emergence of periodontal disease, including Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis, Prevotella intermedia, Tannerella forsythia, and Treponema denticola (2,3). These bacteria infect and cause inflammation and damage to the gingiva, periodontal ligament, root cementum, and alveolar bone. Bacterial infections occur due to host activity or conditions, such as consumption of a high-carbohydrate diet that increases plaque accumulation, poor oral hygiene, immune disorders, physiological stress, or systemic disease (5,6).

Periodontal disease is known to have existed since the stone age and is one of the most common diseases found in humans. The oldest indication of periodontal disease is seen in Neanderthal Krapina and Kabwe Man who lived around 300,000-130,000 years ago (7). Several studies have shown that periodontal disease is found in human populations living from the Upper Paleolithic to the historic period (1,2,4,6). Today, periodontal disease is the sixth most common disease worldwide with an age-standardized prevalence rate of around 11% (5).

This study aims to describe periodontal disease, especially periodontitis, found in individual skeletal remains from the Jauharlin 1 Cave site (GJL1.1). Jauharlin Cave 1 site (Figure 1.) is located in Bangkalaan Dayak Village, Kelumpang Hulu District, Kotabaru Regency, South Kalimantan Province, Indonesia. Individual GJL1.1 was found in research in 2019 held by Regional Agency for Archaeological Research in South Kalimantan (Balai Arkeologi Kalimantan Selatan). The bioskeletal profile and burial contexts of GJL1.1 (Figure 1.) are described in Table 1. The dating test revealed that the GJL.1 individual lived at around 1576 ± 15 BP (1410 cal. BP, Paleometallic period) (8,9). The significance of this study is to provide an overview of the oral and dental health problems of an individual that lived around the Indonesian Paleometallic period, specifically in the Kalimantan region.

Materials and Methods

The material used for this research is the cranium of GJL1.1. The method used in this study is on-site macroscopic observation in 2019 and observation through photos in 2022. The photos used are research documents from 2019, showing the conditions before and after the GJL1.1 cranium was preserved with Paraloid B-72 (Figure 1.). The observations were focused on the condition of periodontitis in the alveolar bone of the maxillary and mandibular teeth. Identification and classification of periodontitis conditions refer to the Ogden scoring system (10): score 0, unable to score (damaged or missing alveolar bone); score 1, the alveolar margin meets tooth at a knife-edged acute angle (no disease); score 2, the alveolar margin is blunt and flat-topped with a slightly raised rim (mild periodontitis); score 3, the alveolar margin is rounded and porous, with a trough of 2–4 mm depth between tooth and alveolar bone (moderate periodontitis); score 4, the alveolar margin is ragged and porous, with an irregular trough or funnel >5 mm depth between the tooth and alveolar bone (severe periodontitis).

Results

The alveolar bone of the maxillary and mandibular teeth of GJL1.1 which were observed were of the right anterior-posterior and left anterior parts. The left posterior dental alveolar bone was not observed because they were still attached to the ground. The teeth of GJL1.1 are in relatively good condition, but not the alveolar bone, especially the maxilla. The alveolar bone of the right maxillary teeth is fragile and fragmentary; a small part of the bone even fell off while cleaning the matrix on the surface of the bone. In contrast, the condition of the alveolar bone of the right mandibular teeth looked more solid and showed no signs of fragility. The observable teeth of GJL1.1 were: right UI1, right UI2, right UC, right UP1, right UP2, right UM1, right UM2, left UI1, left UI2, left UC, right LI1, right LI2, right LC, right LP1, right LP2, right LM1, right LM2, left LI1, and left LI2.

The observation results of GJL1.1 periodontitis conditions are presented in Table 2. Periodontitis

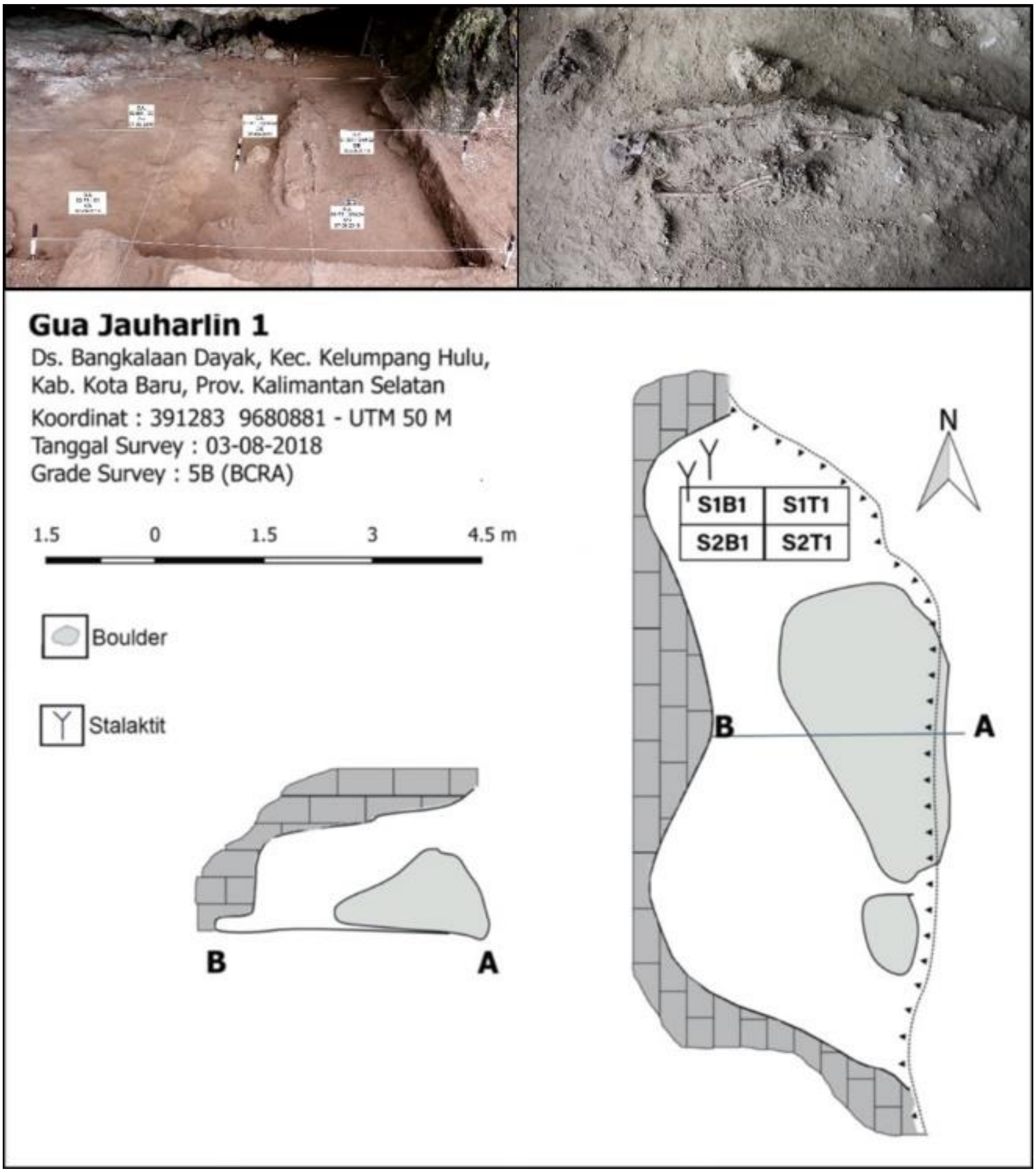

Figure 1 Map of Gua Jauharlin 1 and the position of the excavation box. The upper left photo shows the burial context of GJL1.1 and the upper right photo shows the condition of GJL1.1 after Paraloid-B72 coating.

scores and conditions were divided into 10 alveolar bones of maxillary teeth and 9 alveolar bones of mandibular teeth. In the maxilla, four dental alveolar bones, right UC, right UP1, right UM2, and left UI1, have a score of 0 because they were damaged or missing. Six other dental alveolar bones, right UI1, right UI2, right UP2, right UM1, left UI2, and left UC, have a score of 3 (moderate periodontitis) with the condition of the alveolar margin is rounded and porous, and a trough of 2 mm depth between tooth and alveolar bone (Figure 5.). On the mandible, two dental alveolar bones, right LM1 and right LM2, have a score of 2 (mild periodontitis) with the condition of the alveolar margin being blunt and flat-topped with a slightly raised rim. The other seven dental alveolar bones: right LI1, right LI2, right LC, right LP1, right LP2, left LI1, and left LI2, have a score of 0 because they were damaged or missing. In particular, the damaged or missing alveolar bone

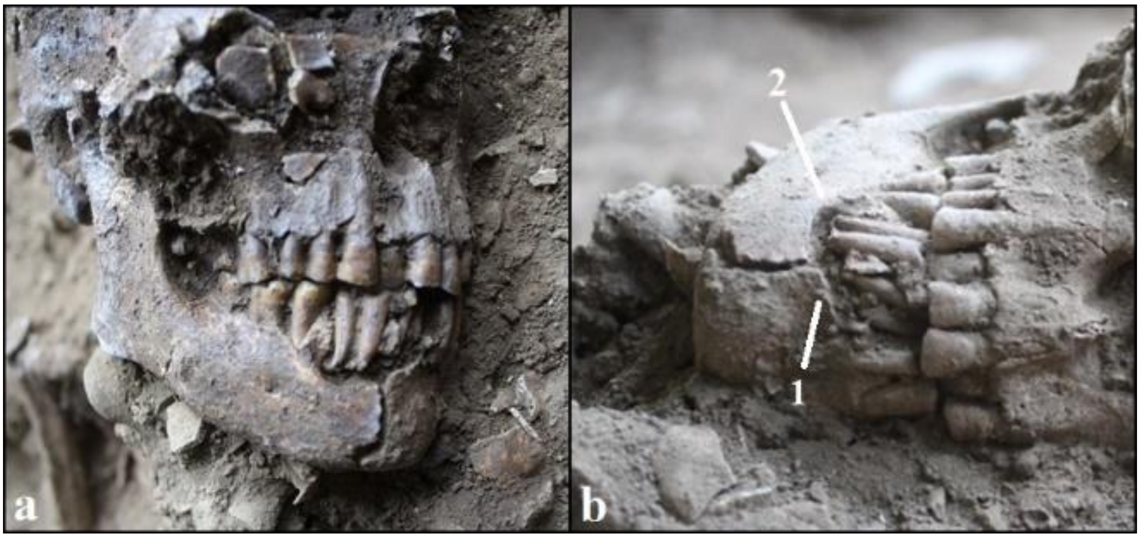

Figure 2 (a) The reddish brown color of the teeth which is suspected as the effect of betel quid chewing is seen more clearly. (b) A hybrid lesion that is suspected on the alveolar bone of mandibular anterior teeth: (1) cyst on right LI1 and right LI2; (2) a chronic abscess on right LC and right LP1), and alveoli of maxillary anterior teeth with moderate periodontitis.

of the right LI1, right LI2, right LC, and right LP1 were suspected to be a result of other problems in the gingiva.

In the right LI1, right LI2, right LC, and right LP1, the damaged or missing alveolar bone results in the exposure of the roots. Its overall characteristics appear to be different from those of the maxillary alveolar bone lost by taphonomic and matrix cleaning processes, and more closely resemble the characteristics of periapical voids lesions. Therefore, the characteristics present in the alveolar bone of these four teeth were identified using the criteria described by Ogden (10) for diagnosing lesions of periapical voids: (1) the lesion must extend from, or incorporate the apices of, one or more tooth root; (2) the void is usually 2-3 mm (granuloma) or larger than 3 mm (cyst) in diameter and is smoothly rounded in shape; (3) the lining of a void is smooth but porous; (4) a void with a thin, sharp margin where it meets the cortical surface of the alveolus representing a cyst, and if the margin is rounded or thickened and the bone appears to have been frequently remodeled, often with a halo of new bone around the orifice, then this represents a chronic abscess.

The identification results of the dental alveolar bone of right LI1, right LI2, right LC, and right LP1 showed the following characteristics: a lesion that extends from the interproximal bone of right LI1- left LR1 to the interproximal bone of right LP1- right LP2; void size larger than 3 mm in diameter; a thin margin that appears to be sticking out on void line under right LI1- right LI2 (Figure 3.); and rounded margin of the void line under right LC- right LP1 (Figure 3.). Two initial characteristics show periapical voids in the alveolar bone of the mandibular anterior teeth formed by cysts. The characteristic thin margin sticking out on the void line under right LI1- right LI2 strengthens the suspicion that the periapical voids in the alveolar bone of the mandibular anterior teeth GJL1.1 were formed due to cysts. On the other hand, the characteristic rounded margin of the void line under right LC- right LP1 indicates two possibilities: first, the cyst developed into a chronic abscess; Second, the lesions seen in the alveolar bone of the mandibular anterior teeth are hybrid, cyst on right LI1- right LI2 and chronic abscess on right LC- right LP1 (Figure 2b).

Discussion

Periodontitis

Several studies suggest that plant-dominant, especially those with high-carbohydrates, possibly lead to an increase in periodontal disease (2,4,5). Periodontitis found in the alveolus of the maxillary and mandibular teeth of GJL1.1 is also thought to be caused by a plant-based diet with high carbohydrates. Phytolith analysis results strengthen this suspicion. The soil sample used for the phytolith analysis was taken from the abdomen to the pelvic cavity (sample code GJL1.TI). As a result, plant residues from the Arecaceae family were found, with a morphotype similar to the Arenga pinnata reference sample (Figure 4.). Other plants found

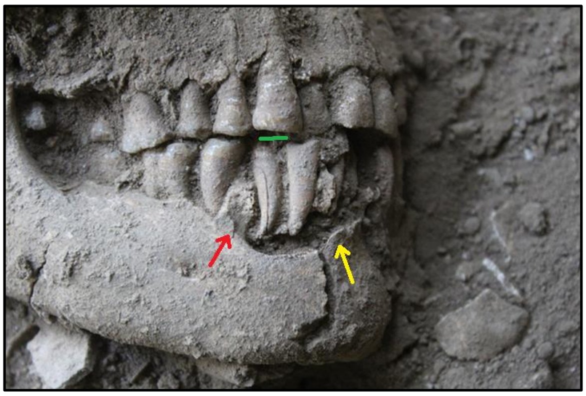

Figure 3 Periapical void characteristics on GJL1.1: lesions extending from the interproximal bone of right LI1- left LI1 to the interproximal bone of right LP1- right LP2; a thin margin that appears to be sticking out on void line under LRI1 and LRI2 (yellow arrow); and rounded margin of the void line under right LC and right LP1 (red arrow). The green line shows the wear pattern of the right LC and right LP1 teeth.

were from the Oryzoideae subfamily (rice), Figure 5. and Musaceae family (banana), Figure 6 (11). Phytoliths from the Arecaceae family, Oryzoideae subfamily, and Musaceae family from GJL1.T1 sediments are indicated as food residues consumed by GJL1.1. In the context of plant-based food, it is known that these plants have been exploited as food since 5000 years ago in southern China, then spread from Taiwan to Southeast Asia as part of the Neolithic migration. Plants from the Arecaceae family, such as the sago palm, were even an important food source before the advent of rice in southern China (12). These plants are known to be high in carbohydrates, which is thought to have affected the emergence of periodontitis in GJL1.1. However, it is not certain how dominant these plants are consumed by GJL1.1. So far there is no data on meat-based food residues from the GJL1.1 burial context that can be used to reconstruct the overall daily diet.

Apart from dietary factors, bacterial infections are also thought to influence the emergence of periodontitis in GJL1.1. Research by Willman et al. (13) demonstrated that oral bacteria play a role in the development of periodontitis and other forms of periodontal disease. Periodontitis-causing bacteria develop and then infect due to frequent high-carbohydrate diets. This type of diet triggers plaque accumulation and mineralization to form dental calculus. Dental calculus can irritate the gingiva, causing inflammation, and developing periodontal disease (1,3).

So far, no calculus or caries have been found on GJL1.1, two things that are usually found together with periodontitis problems due to a high-carbohydrate diet (5,13). There are two assumptions regarding the absence of calculus and caries on GJL1.1: the taphonomic factor causing the disappearance of calculus on the teeth; or calculus never really existing on the teeth due to betel quid chewing. The second notion is based on the reddish-brown discoloration present in the enamel of the maxillary and mandibular teeth (Figure 2a.). Similar conditions are fairly common in archaeological skeletal remains (14) and contemporary betel quid chewers, especially among those that persist in the habit over a long period (15). An indication of the reddish-brown color on GJL1.1 teeth as the effect of betel quid chewing was also strengthened by the results of the phytolith analysis, namely the findings of Areca catechu plant residues (Figure 4.) (11).

Research by Hernandez et al. (16) proved that chewing betel quid for a long time can change the bacterial microbiome in the oral cavity and suppress/reduce its growth. One of the bacteria affected by betel quid is Streptococcus, a genus that is dominant in the oral microbiome. Willmann et al. (13) explained that Streptococcus bacteria are the "chief pathogen" that triggers dental caries. His research also found high levels of S. mutans and S. sanguinis bacteria in the archaeological samples that he studied. In this case, chewing betel quid could reduce the risk of dental caries because the bacteria of the Streptococcus genus as its originator are inhibited. The absence of caries and calculus on the teeth of GJL1.1 might have also been an effect of the betel quid chewing.

That being said, betel quid chewing has an adverse effect on the periodontium as well. Research by Giri et al. (17) and Hsiao et al. (15) showed that betel quid chewing gave rise to gingival lesions and gum recessions, and periodontal pockets. In terms of the bacterial microbiome, apart from inhibiting/reducing the development of certain types of bacteria, betel quid chewing also increases the development of other types of bacteria (16). The negative effects of betel quid chewing are also indicant in GJL1.1. The periodontal pocket was observed in the alveolus of the tooth which was identified as periodontitis and was suspected as the effect of bacterial infection on the periodontium. This condition and betel quid chewing is suspected to be the cause of periapical voids in GJL1.1.

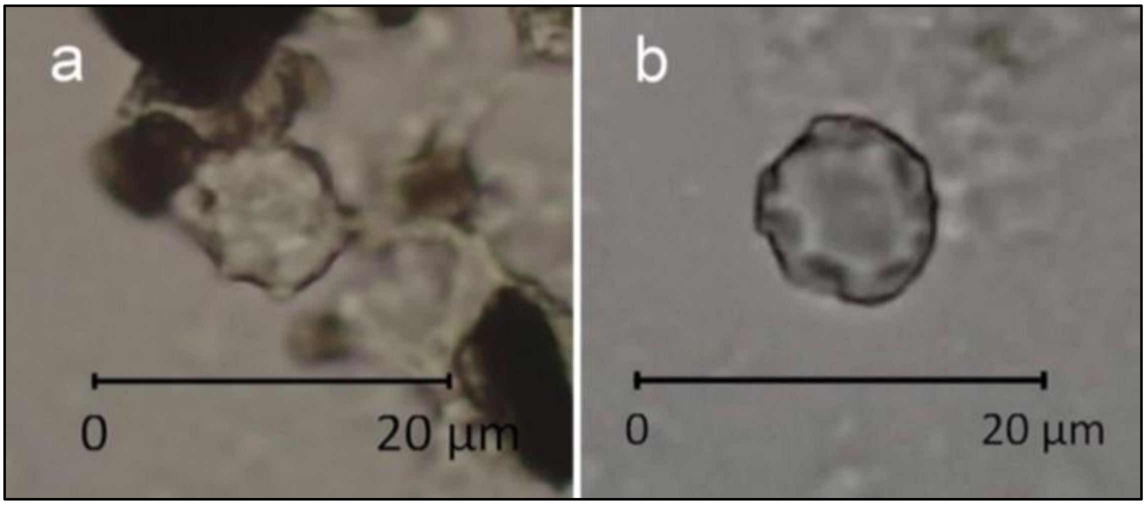

Figure 4 Arecaceae phytolith: (a) Areca catechu dan (b) Arenga pinnata.

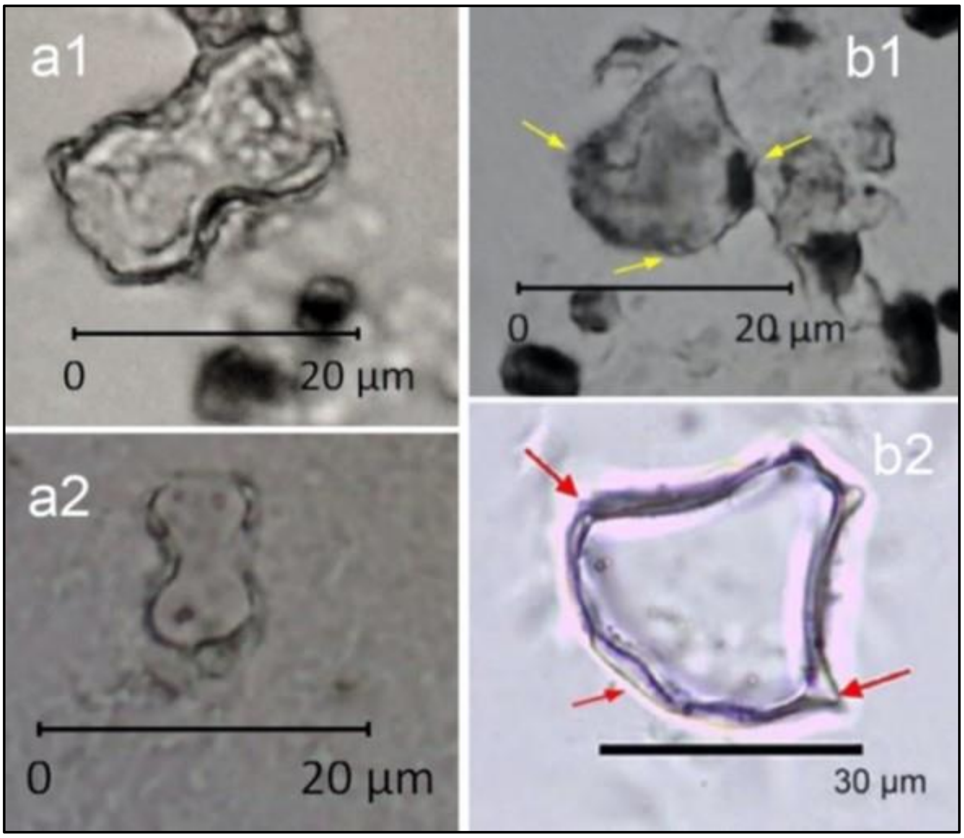

Figure 5. Oryzoideae phytoliths from GJL1.T1 (a1, a2, b1) compared to reference samples from Southern China (b2).

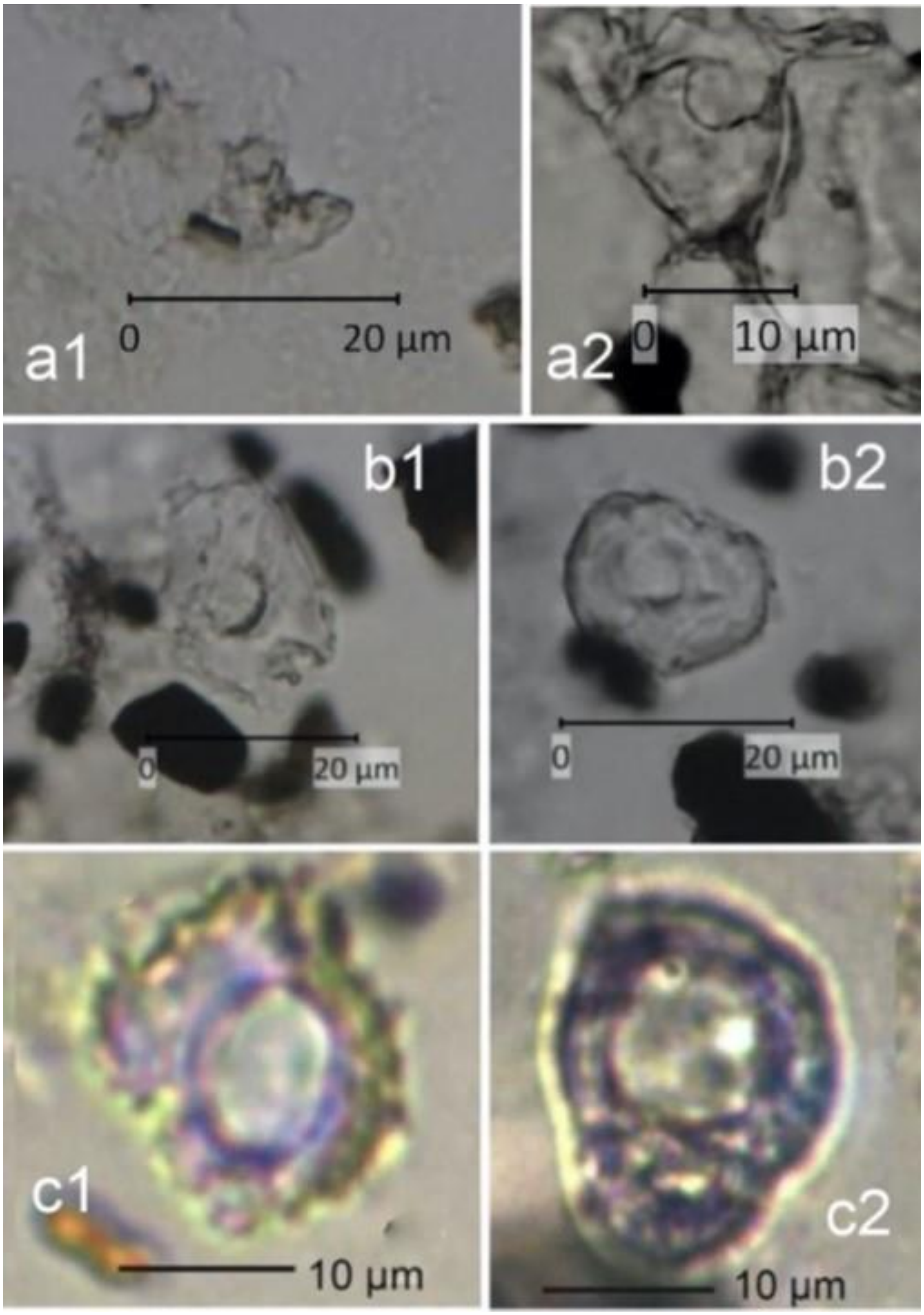

Figure 6. Musaceae-like phytoliths from GJL1.T1 (a1-2; b1-2), and Musaceae phytolith reference samples from Sri Lanka (c1-c2).

Periapical Voids

Periapical voids on GJL1.1 indicate the possibility of a cyst that developed into a chronic abscess, or a hybrid periapical problem (cyst and chronic abscess). A cyst is a cavity in the jaw filled with liquid or paste when a person is alive. The most common type of cyst on the periapical is the radicular cyst that develops from periapical granuloma (18). Abbott (19) explained that a periapical cyst is believed to be a direct sequel to a periapical granuloma, although not every granuloma will develop into a cyst. Clinically, periapical granuloma and periapical cyst (radicular cyst) are classified as chronic apical periodontitis.

Chronic apical periodontitis occurs when an inflammation of the periapical is left untreated. Bacteria in the root canal caused by trauma or irritation to the periapical area can trigger inflammation. Chronic apical periodontitis can become acute apical periodontitis. Gradually, the initial acute inflammation will change to a chronic inflammatory reaction, known histologically as periapical granuloma. Periapical granulomas can persist for a long time, but the equilibrium can be disturbed at any time by any factor that favors the growth and/or migration of the microbial flora. Bacteria can then migrate from the root canal to the periapical tissues and chronic inflammation will become acute (19).

Apical periodontitis can also develop without the root canal system becoming infected. Most of the cases are even described as related to problems with the pulp. The pulp can be subject to long-term irritation from tooth decay, such as caries, fissures, or chemical erosion. In this situation, the dentine is exposed so that bacteria can reach the pulp and cause inflammation. Without proper treatment, pulp inflammation can spread and eventually, pulp necrosis occurs. If the inflammation spreads through the apical foramen, apical periodontitis may develop. Without treatment, the next possible reaction is cyst formation or abscess formation (19).

The periodontal abscess is caused by bacteria entering the wall of the tooth cavity and causing inflammation, with the effects of the destruction of connective tissues, encapsulation of bacterial infection, and production of pus. Pus localized to the gingival wall of the periodontal area leads to the destruction of the attached collagen fibers and subsequent loss of the adjacent alveolar bone (3). Several studies have shown that a periodontal abscess is a common clinical finding among patients with moderate to advanced periodontitis (19). Periodontal abscesses and associated bacterial infections have been described as a cause of death (20).

Judging from the presence of previous periodontitis conditions in GJL1.1 and its possible causes, the periapical voids identified in GJL1.1 may also be caused by betel quid chewing. Research by Hernandez et al. (16) explained that chewing betel quid regularly can cause irritation and chronic inflammation; which damage the epithelial cells of the oral cavity. Periapical inflammation occurs due to the lime mixture in betel quid (17,21), a common ingredient added by betel quid chewers. How it is consumed can also affect the appearance of inflammation. Betel quid that has been chewed is rubbed over the entire surface of the gingiva and teeth, then held in the labial-buccal area of the maxillary or mandibular cheek cavity (22). It is this mixture of betel quid ingredients and method of consumption that is thought to be the cause of irritation to the right anterior periodontal area of GJL1.1. In this case, betel quid chewing created a periodontal pocket which becomes a medium for bacteria to infect.

The chronic apical periodontitis experienced by GJL1.1 may also be affected by problems with the pulp. The basis for this assumption was the condition of the right LC and right LP1 teeth which exposed the dentin and pulp (Figure 3.). This condition is thought to have been caused also by betel quid chewing. Rooney (22) explains that the anterior teeth often hold the betel quid in place before chewing. This custom is common among betel quid chewers in Southeast Asia. After chewing, the betel quid is also still held in the labial-buccal area of the maxillary or mandibular cheek cavity for occasional chewing and sucking to extract liquid from the betel quid. If such chewing habits are carried on over a long period, the occlusal surfaces of the teeth would wear out at a high rate. It was this habit that exposed the dentine and pulp of the right LC and right LP1 teeth of GJL1.1. Bacteria can easily reach the pulp and cause inflammation.

Inflammation then is not treated properly, causing certain types of bacteria in the oral cavity to develop and infect, and may lead to chronic apical periodontitis. However, it is possible that GJL1.1 had considered chewing betel nuts as a way to treat his periapical inflammation as arecoline in betel quid can act as an anti-inflammatory and be used to treat pain (23). This may have led GJL1.1 to continue chewing betel quid to manage pain due to inflammation in the gingiva, in addition to possible addictive effects (23). In this case, betel nut chewing increased the risk of bacterial infection, resulting in a periapical abscess.

Conclusion

Periodontitis on individual GJL1.1 is thought to be caused by a plant-based diet with high carbohydrates. Phytolith analysis of GJL1.T1 sediment found remains of high-carbohydrate plants, Arecaceae family, Oryzoideae subfamily, and Musaceae family that strengthen this suspicion. Another factor that is thought to have affected the periodontitis found on GJL1.1 is betel quid chewing. This habit could have triggered bacteria development in the oral cavity and caused inflammation along with periodontitis.

Table 1. Individual profile and burial context of GJL1.1

Sites	Gua Jauharlin 1 (Jauharlin 1 Cave)
Location	Bangkalaan Dayak Village, Kelumpang Hulu District, Kotabaru Regency, South Kalimantan Province, Indonesia
Cultural Affiliation	Paleometallic
Date	1576 ± 15 BP (1410 cal. BP) (radiocarbon dating laboratory, University of Waikato, New Zealand)
Feature	Grave 1
Location of Grave	S1T1-S1B1
Burial and Grave Type	A single primary burial, east (head) – west (foot) orientation, head facing to the south (rock art features on the roof of the cave), extended lower limb, straight arms position
Associated Materials	Molluscs fragments, pottery fragments, flakes
Preservation and Completeness	Skeleton without foot, poor preservation with most elements fragmentary; cranium is fairly preserved; teeth, good preservation
Population Affinity	Asian/Mongoloid
Sex and Basis Determination	Male, based on cranial characteristics, humerus head diameter, and STR CODIS
Age at Death and Basis Estimation	26,9 – 42,5 years old, mean 34,7 years old, based on cranial vault suture
Stature and Basis Estimation	155 cm – 165 cm, based on femur length
Condition Observed	Dental staining (unintentional), the effect of betel nut chewing
Specialized Analysis	STR CODIS, phytolith analysis
Excavation	2018-2019, by Nia Marniati Etie Fajari, Research Center for Archaeometry, National Research and Innovation Agency
Archaeological Report	Fajari et al. (2019)
Current Disposition	Gua Jauharlin 1 (Jauharlin 1 Cave)

Table 2. Score and condition of periodontitis on individual GJL 1.1

No	Teeth	Score	Condition
1	Right UI1	3	Alveolar margin is rounded, with a trough of 2 mm depth between the tooth and alveolar bone
2	Right UI2	3	Alveolar margin is rounded, with a trough of 2 mm depth between the tooth and alveolar bone
3	Right UC	0	Alveolar bone missing
4	Right UP1	0	Alveolar bone damaged
5	Right UP2	3	A trough of 2–4 mm depth between the tooth and alveolar bone
6	Right UM1	3	Alveolar margin is rounded, with a trough of 2 mm depth between the tooth and alveolar bone
7	Right URM2	0	Closed with matrix
8	Left UI1	0	Alveolar bone damaged
9	Left UI2	3	Alveolar margin is rounded, with a trough of 2 mm depth between the tooth and alveolar bone
10	Left UC	3	Alveolar margin is rounded, with a trough of 2 mm depth between the tooth and the alveolar bone
11	Right LI1	0	Alveolar bone damaged/missing
12	Right LI2	0	Alveolar bone damaged/missing
13	Right LC	0	Alveolar bone damaged/missing
14	Right LP1	0	Alveolar bone damaged/missing
15	Right LP2	0	Alveolar bone damaged/missing
16	Right LM1	2	Alveolar margin is blunt and flat-topped with a slightly raised rim
17	Right LM2	2	Alveolar margin is blunt and flat-topped with a slightly raised rim
18	Left LI1	0	Alveolar bone missing
19	Left LI2	0	Alveolar bone missing

Periapical voids detected in the alveolar bone of the anterior teeth GJL1.1 might have been a cyst that developed into a chronic abscess, or a hybrid periapical problem (cyst and chronic abscess). Its appearance is also suspected due to betel quid chewing. Chewing betel quid exposes the pulp of the right LC and right LP1 GJL1.1 teeth so that bacteria can infect and cause periapical inflammation. The periapical abscess that appears later is very likely to be the cause of death for GJL1.1 individuals.

Declaration of Interest

None

Author Contributions

DBM: design of the study, formal analysis, writing-original draft and writing-review. NMET: data curation and formal analysis. TK: formal analysis, supervision and critical review of the present study.

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